COURSE CODE	COURSE TITLE	L	T	P	C
1153AE102	**CONSTRUCTAL THEORY AND DESIGN**	**3**	**0**	**0**	**3**

Course Category:

Allied Elective

a. Preamble :

The course brings together the basic principles of fluid mechanics, heat transfer and thermodynamics, and teaches how to generate (to 'discover') shape and structure for energy flow systems. This course teaches design as science, and presents a paradigm that is applicable across the board, from engineering to biology, geophysical and social dynamics

b. Prerequisite Courses:

Engineering Mechanics, Strength of Materials, Fluid Mechanics, Thermodynamics and Heat Transfer

c. Related Courses:

d. Course Educational Objectives :

- To bring together the principles of solid mechanics, dynamics, fluid mechanics, heat transfer and thermodynamics, and use them to generate (to 'discover') the designs (configurations, shapes, structures) of energy flow systems, natural or engineered.
- To show how the flow configuration emerges from the Constructal law of design and evolution in nature: the natural tendency to generate designs that facilitate flow access in time, when the flow system is endowed with freedom to morph.

e. Course Outcomes :

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Explain the basic concepts involved in the Constructal Theory and Design	K2
CO2	Apply the principles of solid mechanics, dynamics, fluid mechanics, heat transfer and thermodynamics, to describe the functioning of flow systems	K3
CO3	Integrate the various aspects of flow system operation (solid mechanics, fluid mechanics, heat transfer, thermodynamics) to establish the connection between system global performance and system configuration	K5
CO4	Select the configuration that promises the highest (or almost highest) performance	K3
CO5	Identify a flow system or category of flow systems in nature and analyze it according to the outcomes 2-4 above	K4

Correlation of COs with POs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H		M			H	M	H				H
CO2	H		M			H	M	H				H
CO3	H		M			H	M	H				H
CO4	H		M			H	M	H				H
CO5	H		M			H	M	H				H

H- High; M-Medium; L-Low

f. Course Contents :

UNIT-I INTRODUCTION AND BASIC CONCEPTS L-9

Objective, constraints, configuration- Flow- Fluid Flow Internal Flow: Distributed Friction Losses, Local Losses - External Flow - Heat Transfer – Conduction- Convection Imperfection-Evolution toward the Least Imperfect Possible - Thermodynamics - Closed Systems - Open Systems - Analysis of Engineering Components - Heat Transfer Imperfection – Fluid Flow Imperfection - Other Imperfections - Optimal Size of Heat Transfer Surface

UNIT-II SIMPLE FLOW CONFIGURATIONS L-5

Simple Flow Configurations - Flow between Two Points, Optimal Distribution of Imperfection, Duct Cross Sections - River Channel Cross-Sections - Internal Spacings for Natural Convection , Learn by Imagining the Competing Extremes, Small Spacings, Large Spacings

UNIT-III CONFIGURATIONS FOR FLUID FLOW AND HEAT CONDUCTION L-11

Tree Networks for Fluid Flow - Optimal Proportions: T- and Y -Shaped Constructs - Optimal Sizes, Not Proportions - Trees Between a Point and a Circle- Performance versus Freedom to Morph - Minimal-Length Trees - Strategies for Faster Design - Trees Between One Point and an Area - Asymmetry - Three-Dimensional Trees - Loops, Junction Losses and Fractal-Like **Trees Configurations for Heat Conduction -** Trees for Cooling a Disc-Shaped Body - Conduction Trees with Loops - Trees at Micro and Nanoscales - Evolution of Technology: From Forced Convection to Solid-Body Conduction

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UNIT-IV MULTISCALE AND MULTIOBJECTIVE CONFIGURATIONS L-12

Distribution of Heat Sources Cooled by Natural Convection - Distribution of Heat Sources Cooled by Forced Convection - Multiscale Plates for Forced Convection - Multiscale Plates and Spacings for Natural Convection - Multiscale Cylinders in Crossflow -Multiscale Droplets for Maximum Mass Transfer Density

Multiobjective Configurations- Thermal Resistance versus Pumping Power - Elemental Volume with Convection - Dendritic Heat Convection on a Disc - Dendritic Heat Exchangers Constructal Heat Exchanger Technology - Tree-Shaped Insulated Designs for Distribution of Hot

Water Vascularized Materials - The Future Belongs to the Vascularized: Natural Design Rediscovered - Line-to-Line Trees – Counter flow of Line-to-Line Trees - Self-Healing Materials - Vascularization Fighting against Heating - Vascularization Will Continue to Spread

UNIT-V MECHANICAL AND FLOW STRUCTURES L-8

Mechanical and Flow Structures Combined - Optimal Flow of Stresses - Cantilever Beams - Insulating Wall with Air Cavities and Prescribed Strength - Mechanical Structures Resistant to Thermal Attack Vegetation

Quo Vadis Constructal Theory - The Thermodynamics of Systems with Configuration - Two Ways to Flow Are Better than One - Distributed Energy Systems - Scaling Up - Survival via Greater Performance, Svelteness and Territory - Science as a Constructal Flow Architecture

Total: 45 Periods

g. Learning Resources

i. Text Books:

1. A. Bejan and S. Lorente, Design with Constructal Theory, Wiley, 2008.

ii. References:

1. A. Bejan and J. P. Zane, Design in Nature. How the Constructal Law Governs Evolution in Biology, Physics, Technology, and Social Organization, Doubleday, 2012.
2. A. Bejan, Shape and Structure, from Engineering to Nature, Cambridge University Press, 2000.
3. A. Bejan, The physics of Life: The Evolution of Everything, St. Martin’s press, 2016
4. A. Bejan and G. W. Merkx, eds., Constructal Theory of Social Dynamics. New York: Springer, 2007.

iii. Online resources

ii. Lecture plan:

Content Delivery methods:

1. Lecture 2.Lecture with discussion 3.Lecture with demonstration 4.Tutorial 5.Project 6.Assignments 7.seminar 8.Case study 9.Group discussion 10.Asynchronous Discussion 11.Problem based learning 12.Project based learning 13.One minute paper 14.Peer instruction 15.Conceptest 16.Think pair share square 17.Jig saw method 18.Flip-flop